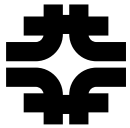


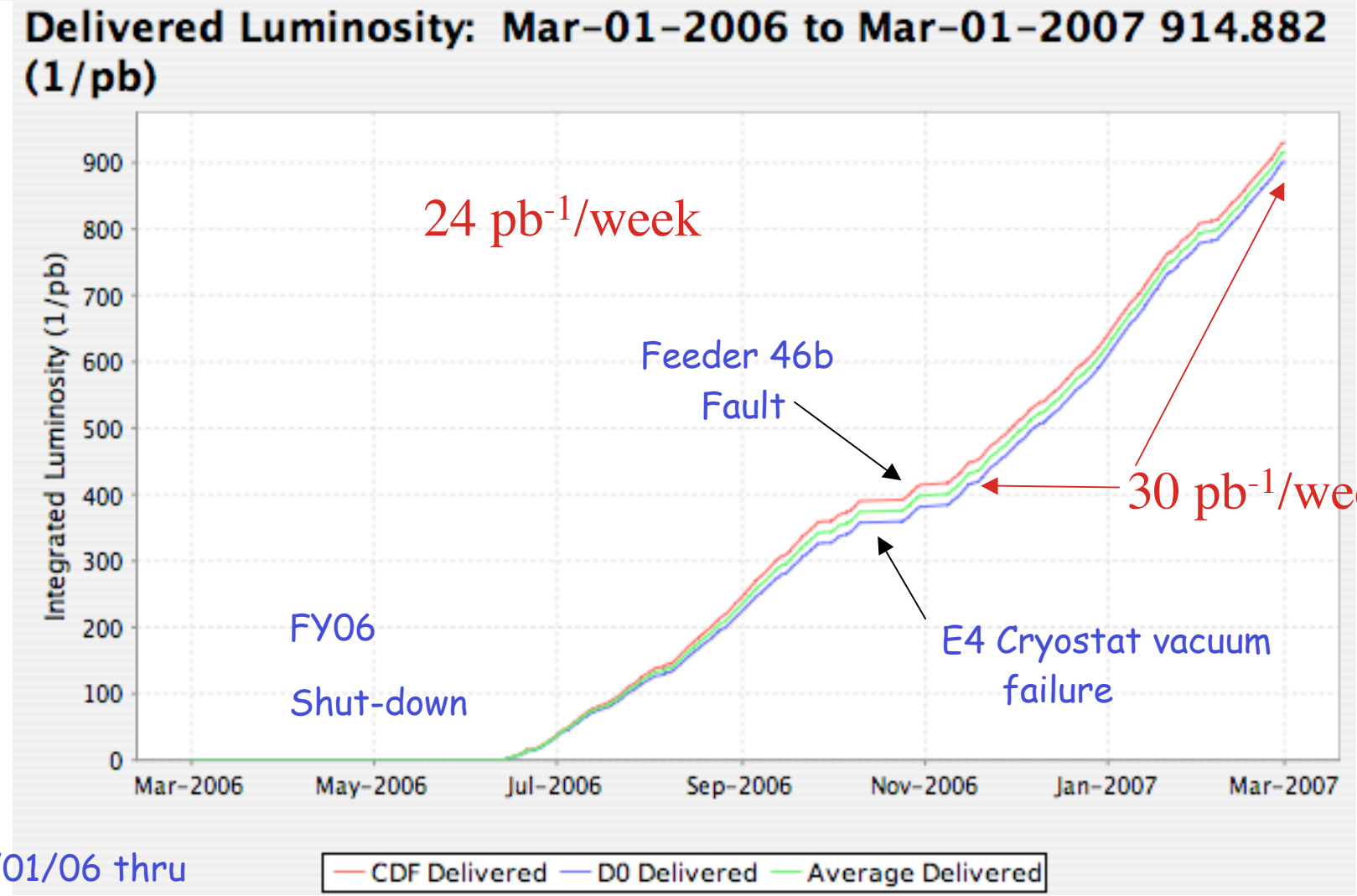
# Run II Operations: Current Status and FY07-09 Plan

R. Dixon

# Overview

- Review of performance since March 2006 review
  - Luminosity/unscheduled downtime
  - Machine Highlights
- Luminosity projections through FY09
  - Risk elements/plan for meeting the design curve
- Safety plan and statistics
- Resource requirements and resource management
- Response to major recommendations from 2006 review

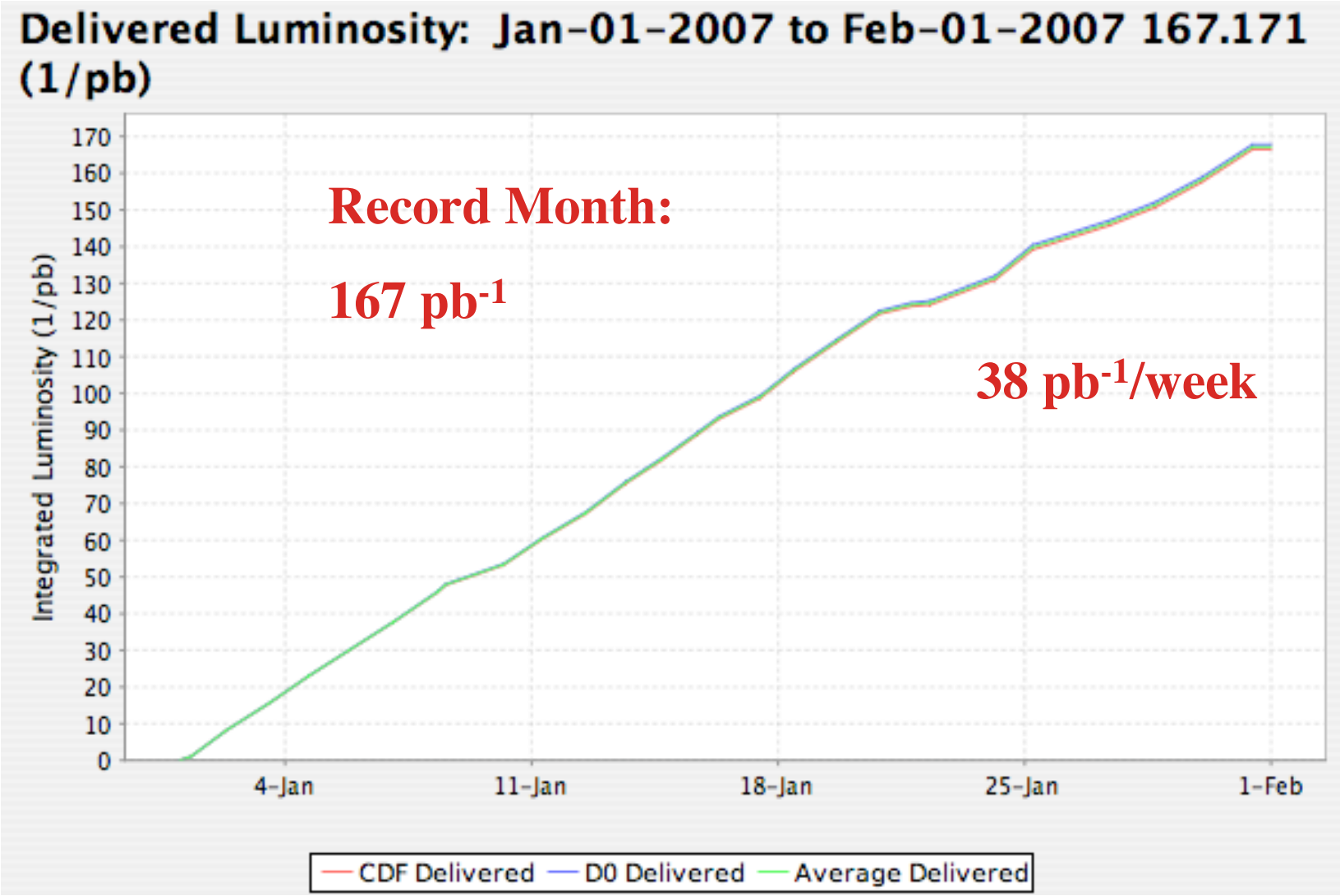
# Integrated Luminosity




3/01/06 thru

3/01/07

# Integrated Luminosity for January 2007



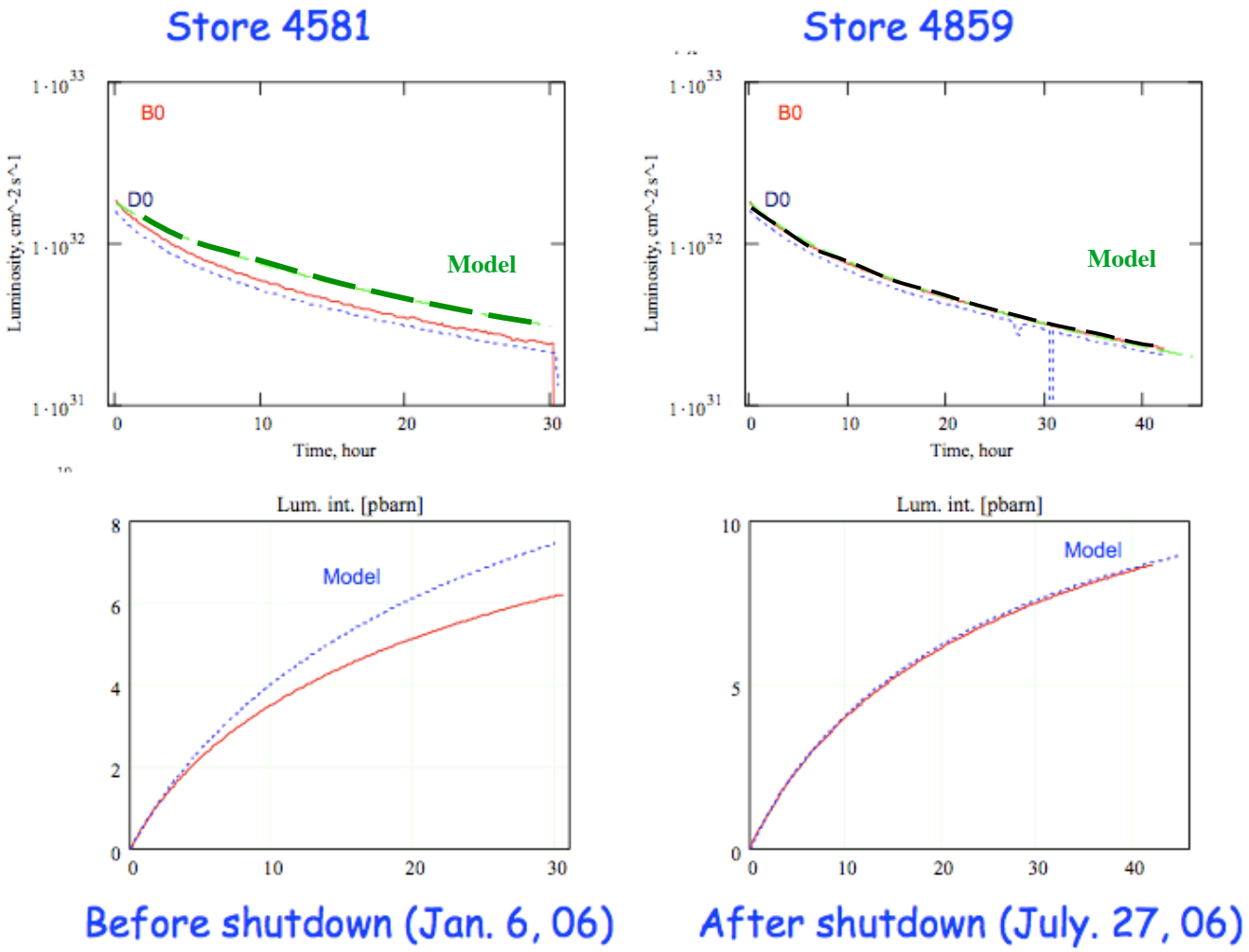
# Records

- Comparing before and after 2006 shutdown data
  - Peak Luminosity has gone up by 62% (180 E30 --> 292 E30)
  - Weekly integrated Luminosity Record has gone up by ~ 75% (25 $pb^{-1}$ --> 45 $pb^{-1}$ )
  - Monthly integrated luminosity has gone up by ~ 95% (85 $pb^{-1}$ --> 167 $pb^{-1}$ )
  - Numerous peak luminosity records were set during this period
  - One hour stacking record-- 23.1 ma/hr
  - Antiproton accumulation for one week-- 2800 E10

# Contributing Factors

- Tevatron
  - More reliable and predictability since the summer shutdown
    - Better lifetimes
    - Predictable lifetimes
  - Shutdown Activities
    - Warmed up 6 houses-- repaired all leaks
    - Replaced all Kautzky valves
    - Alignment
    - TEL 2 installation
    - TEL 1 Repair
    - 2 new separators --> Better Helix (3 Separators replaced)
  - After shutdown
    - Orbit stabilization implemented
    - Increased proton and antiproton intensities

# Tevatron Lifetimes



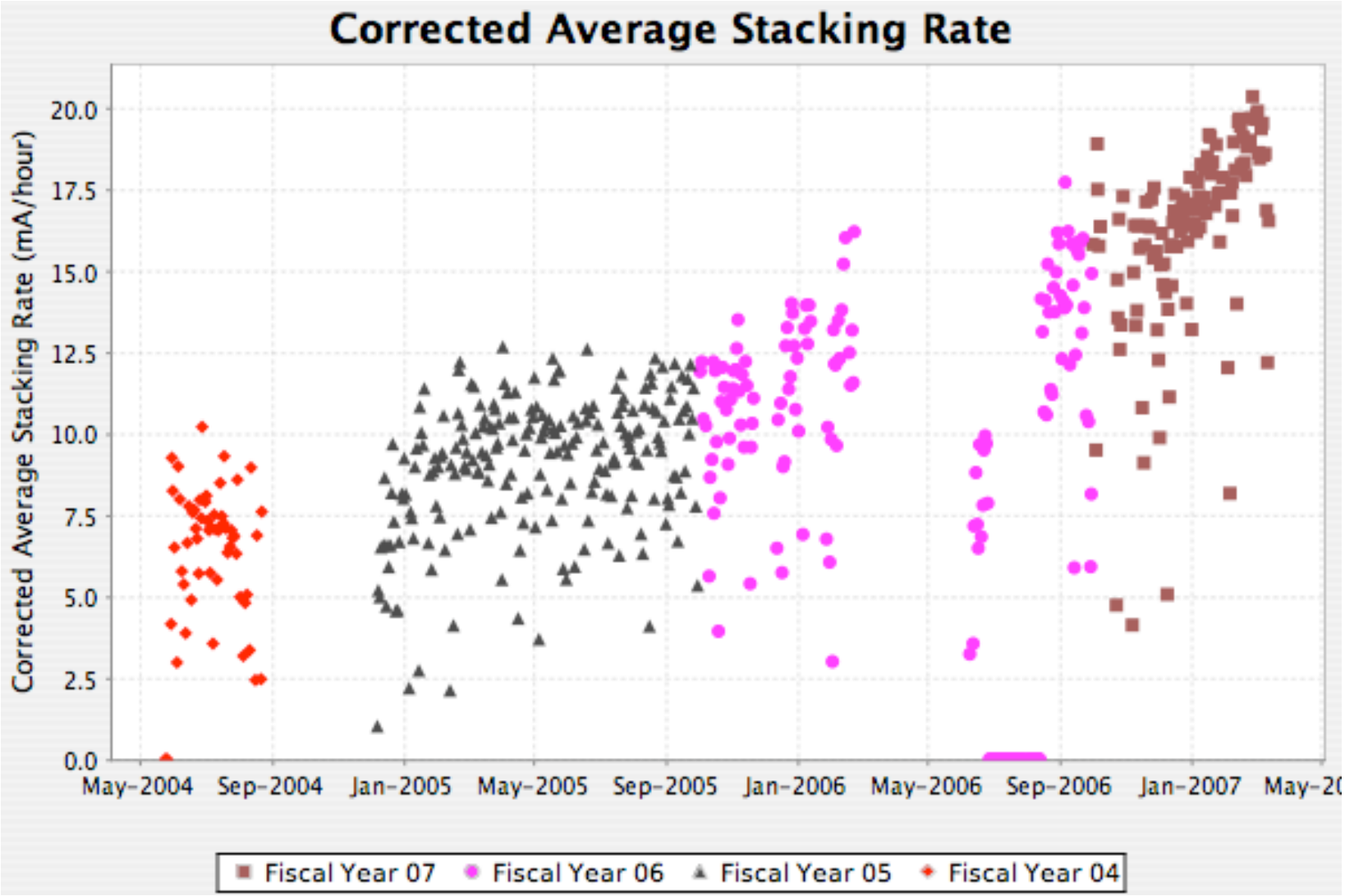

Tevatron Luminosity and Luminosity Evolution Model, V. Lebedev, January 30, 2007, FNAL

8

# Other Items / Things To Do--Tevatron

- TEL-2 demonstrated "safe" beam-beam compensation during HEP
  - Increases proton lifetime – raises vertical tune of individual bunches – little emittance growth
  - Plan to try simultaneous operation with TEL-1
- Scraping now several minutes faster
  - Lose fewer protons, start HEP sooner with higher intensities
- New antiproton cogging for acceleration
  - Move pbars out of abort gap to prevent F4 quenches on abort (reliability)
- Partially implemented new sextupole circuits
  - Correct second-order chromaticity @ low _ ⇒ better lifetime
  - ¬ Also required for possible new working point
- Investigating new cogging between antiproton injections
  - Improve proton efficiency @ 150 GeV?
- Scrape (higher intensity) protons @ 150 GeV
  - Remove beam that would be lost anyway on ramp and squeeze
  - Get "brighter" protons to HEP?

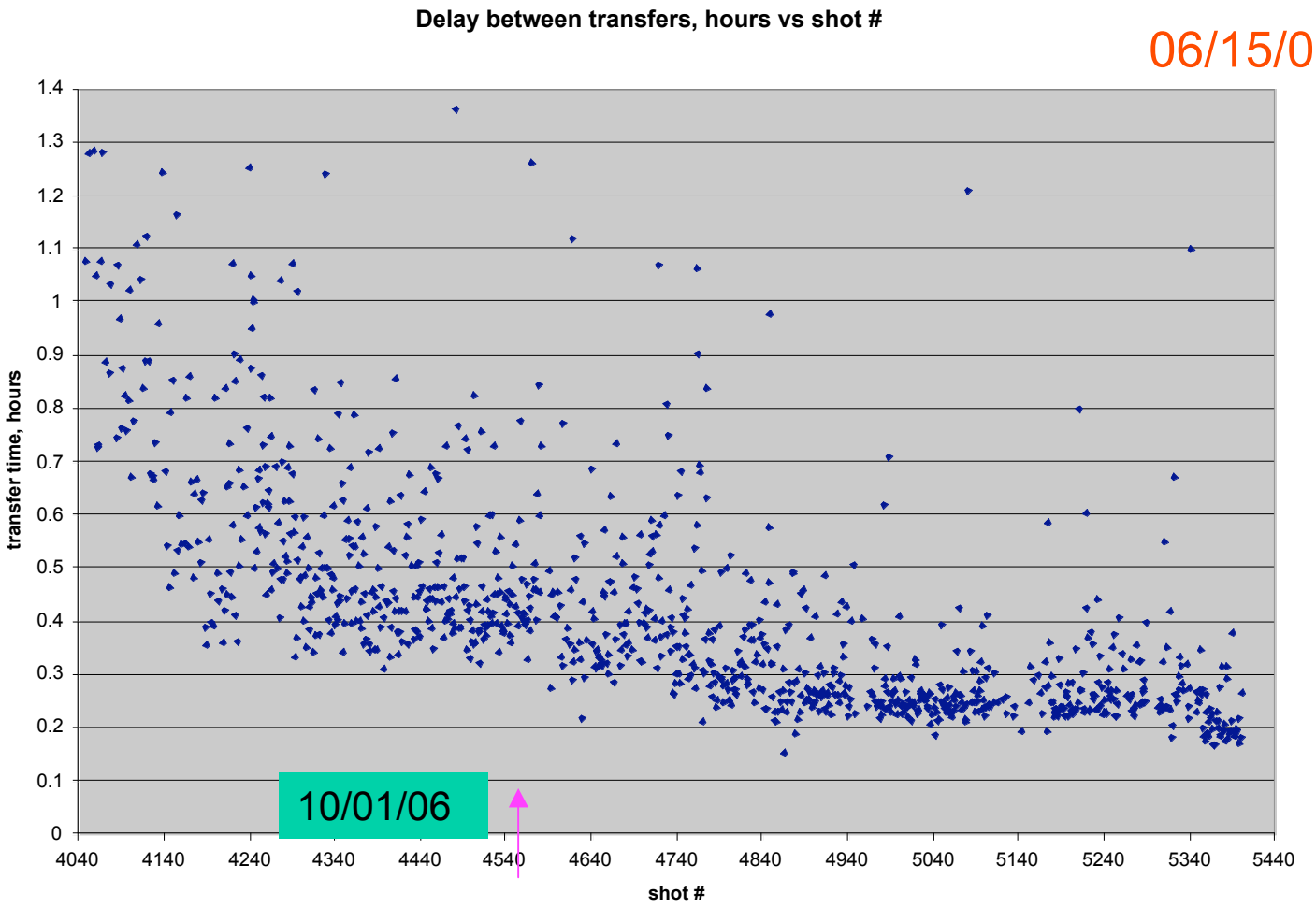
# Stacking Rate



# Antiproton Improvements

- Antiprotons to Tevatron up--45%
  - Stacktail gain correction-- 12%
  - Fast Transfers-- 10%
  - Recycler to Tevatron transfer efficiency-- 6%
  - Misc (Reliability, etc.) -- 11%
- Other factors
  - Lithium Lens-- increasing gradient
  - Lebedev Model to understand stacktail-- good match to data
    - Stacktail identified as major bottleneck
  - Bunch to Bunch intensity leveling for experiments

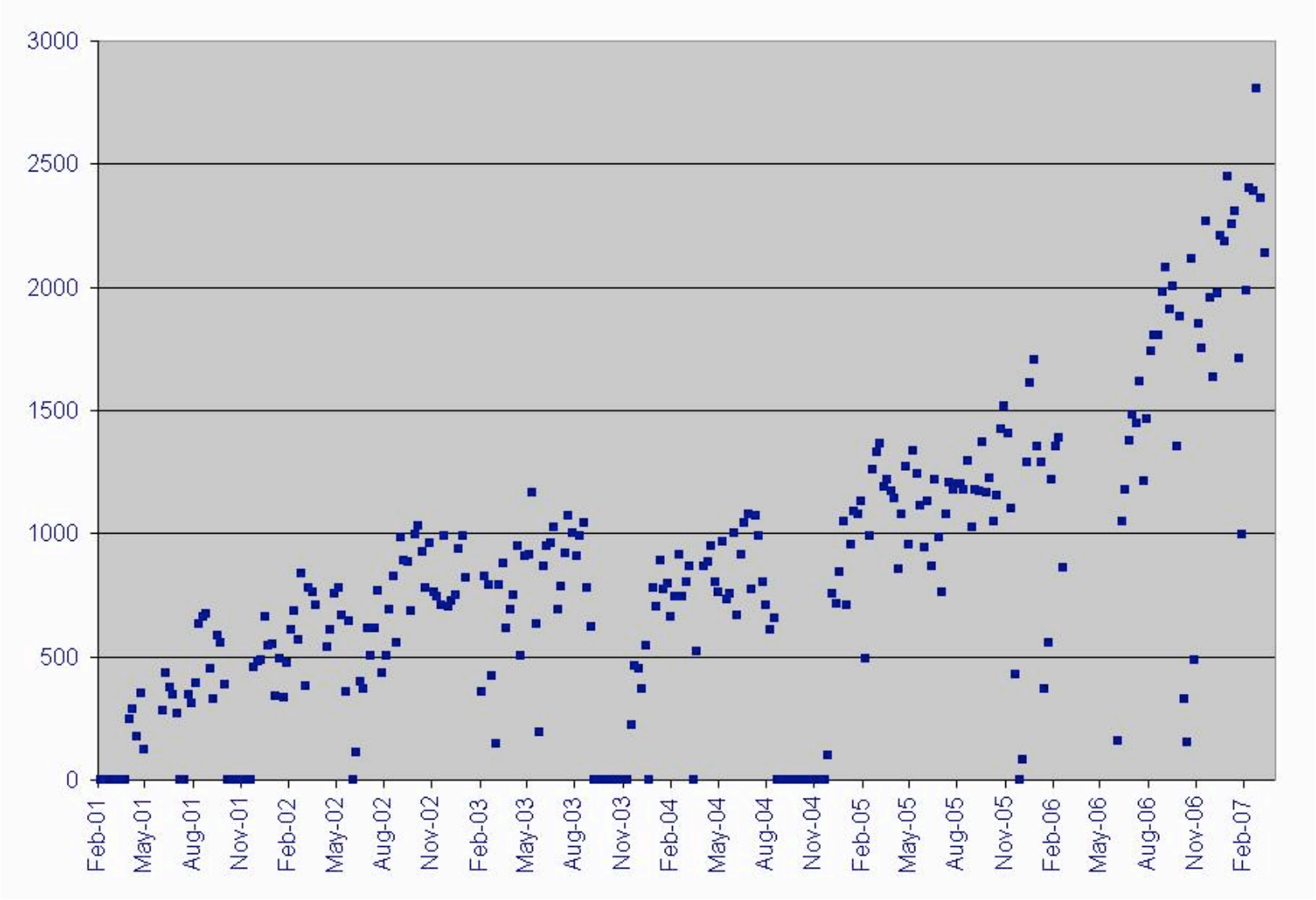
# Transfer Times



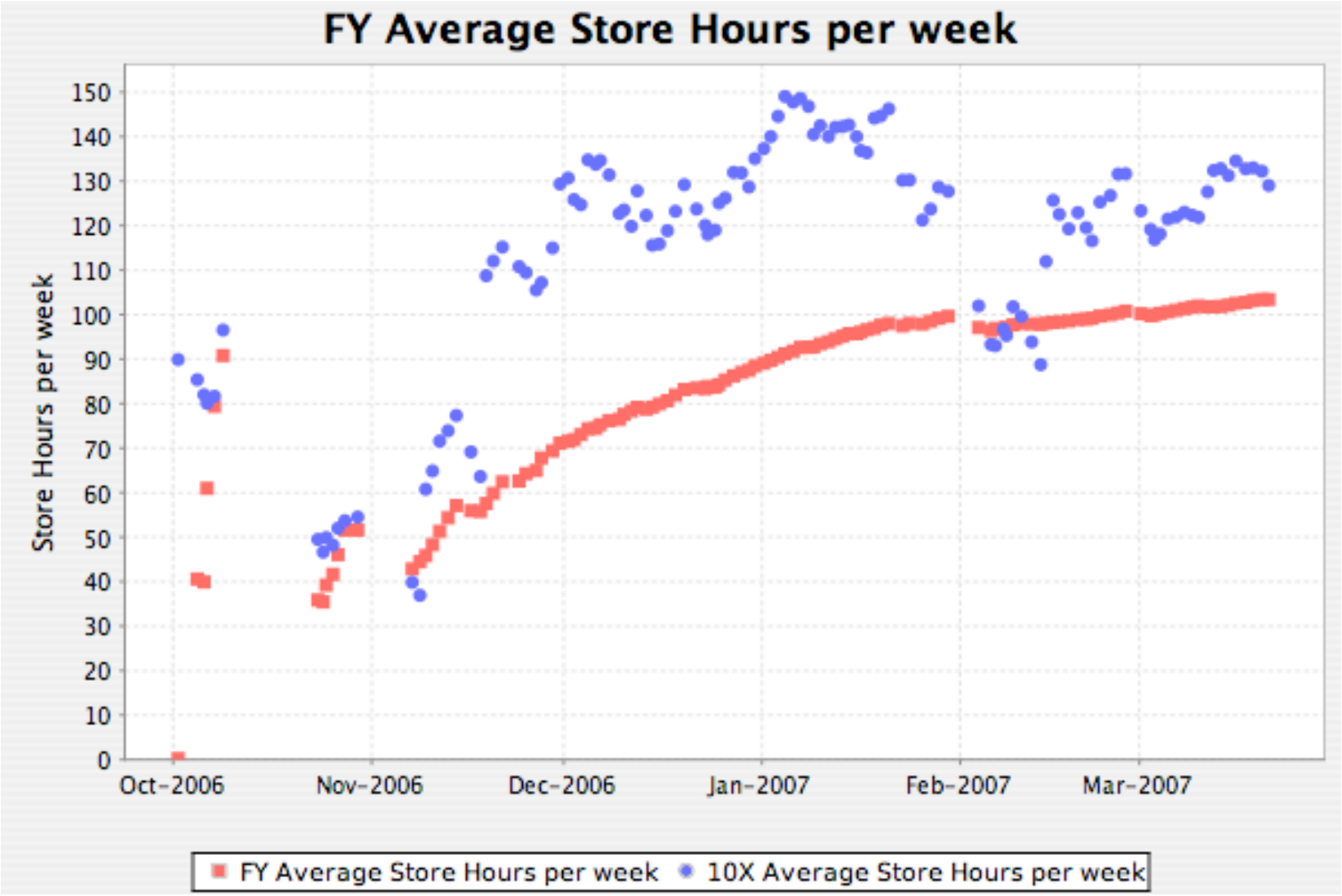

AVG: 0.58 h

STD DEV: 0.62 h

# Weekly Antiproton Accumulation



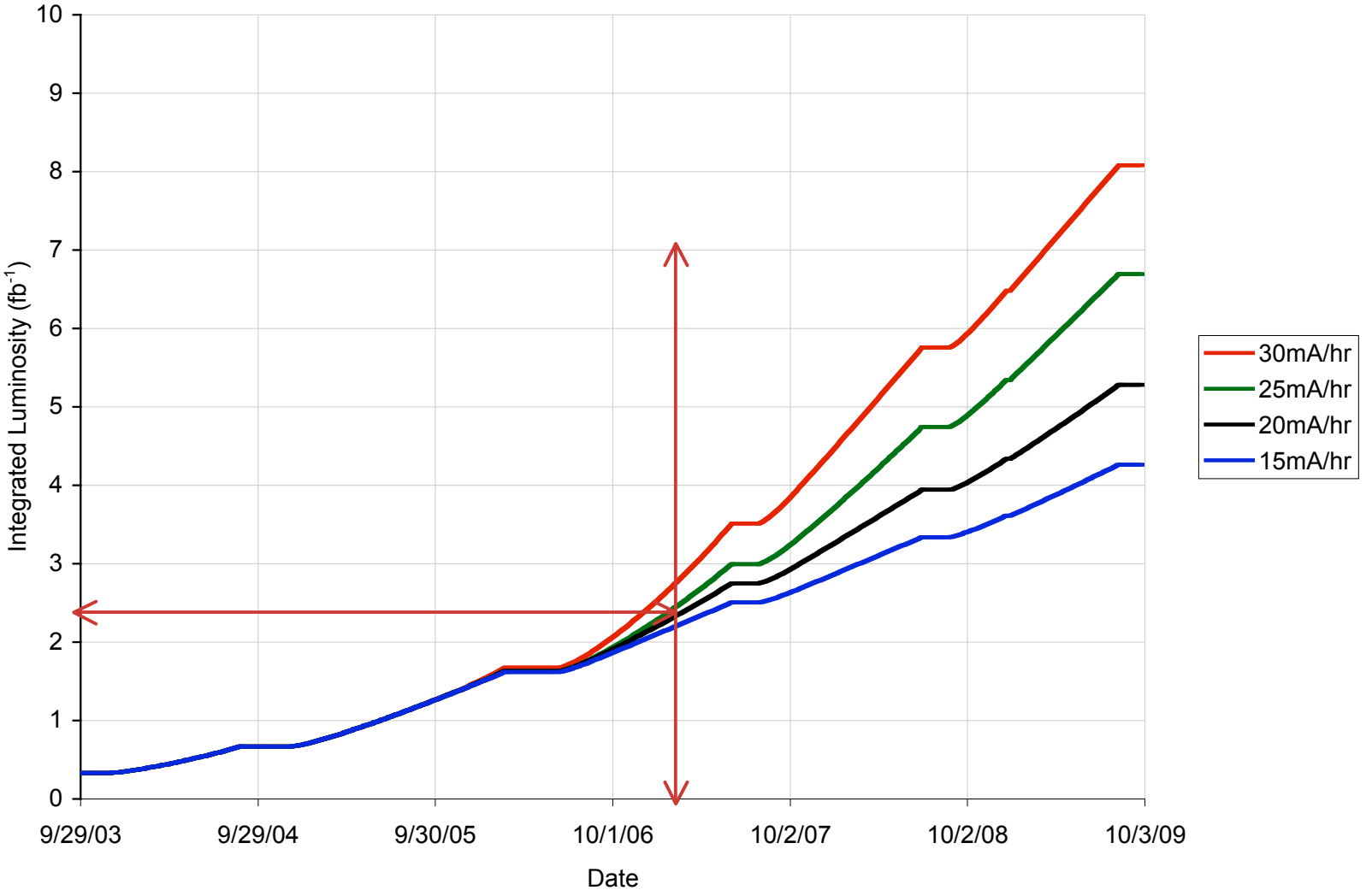
# Store Hours


FY Average Store Hours per week
Store Hours per week
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Oct-2006
Nov-2006
Dec-2006
Jan-2007
Feb-2007
Mar-2007
FY Average Store Hours per week
10X Average Store Hours per week

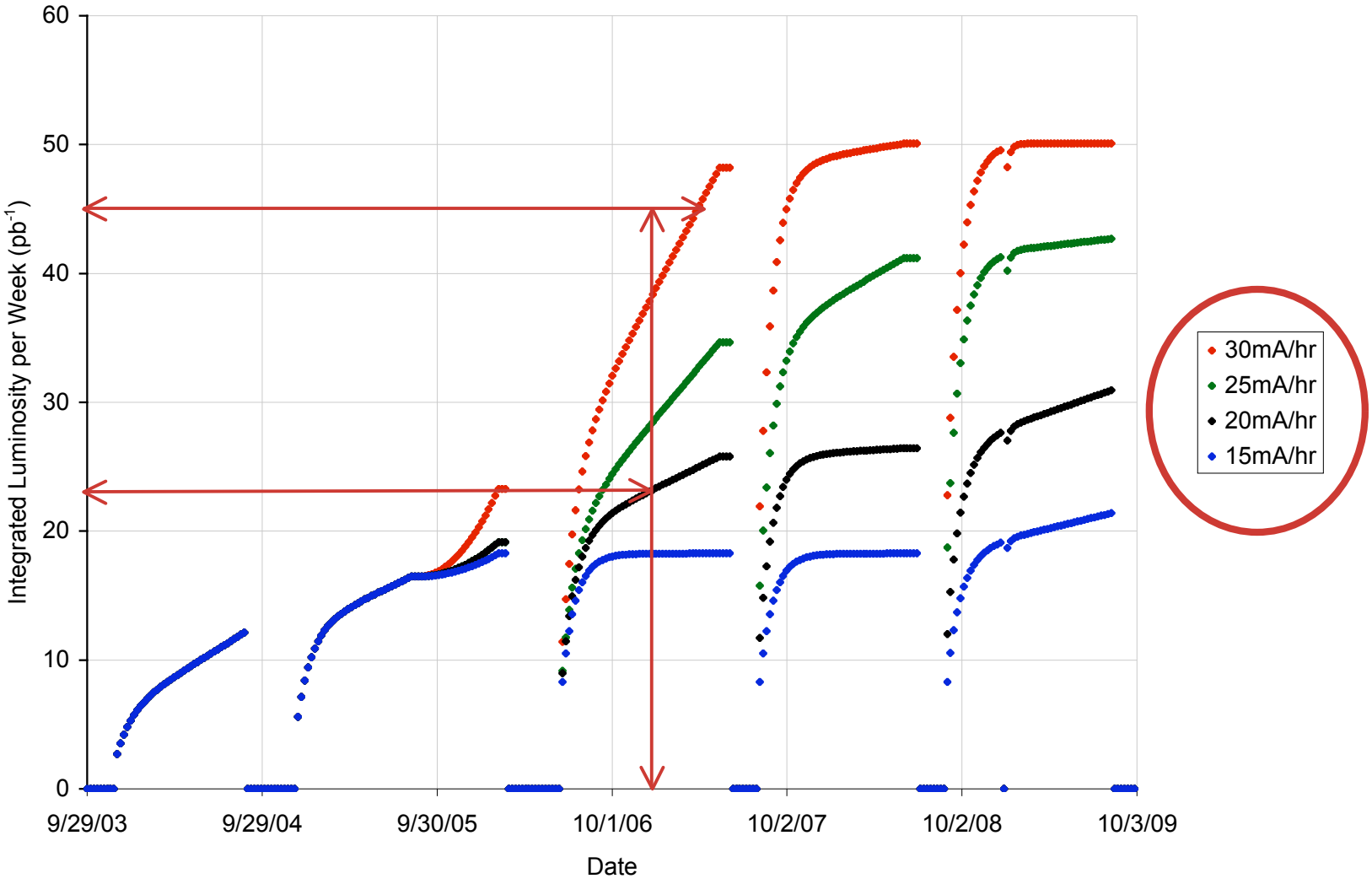
# Plan

- Near term
  - Increase stacking rate
    - Optimize new equalizer
    - Begin working on equalizer #2
  - Slowly increase stash size in the Recycler
    - Make certain it is stable and reliability is good
    - Lifetime issues
  - Increase store length and peak luminosity
    - Beam-beam
    - Lifetimes
  - Continue to optimize proton intensities in the Tevatron
  - Optimize with experiments as part of the equation
- Longer Term
  - Commission new sextupole circuits in Tevatron
  - Continued improvements to stacking
    - New Accumulator Lattice
  - Continue to work on reliability in all machines

# 2006 Projection Curves



# Projected Weekly Luminosity



# Parameters for Projections

- Number of protons per bunch
- Luminosity Density @ 100 x $10^{10}$
- Luminosity Density @ 300 x $10^{10}$
- Init Tevatron Lifetime @ 80 $\mu b^{-1}$/sec
- Init Tevatron Lifetime @ 160 $\mu b^{-1}$/sec
- HEP store hours per week
- Acc-Rec Transfer Efficiency @ 0x$10^{10}$
- Acc-Rec Transfer Efficiency @ 300x$10^{10}$
- Acc-Rec transfer time
- Recycler mining efficiency
- Recycler lifetime
- Initial Stacking Rate

- Half rate stack size
- Maximum stack size
- Timeline Utilization Factor
- Accumulator leftover factor

The output (initial, integrated lum.) depends on the average store length and the number of antiproton transfer shots between stores.

# Inputs to Match Actual Luminosity Curves

- Number of protons per bunch 250 x $10^9$
- Luminosity Density @ 100 x $10^{10}$ 62.5 $\mu b^{-1}$ / sec
- Luminosity Density @ 300 x $10^{10}$ 180.4 $\mu b^{-1}$ / sec
- Init Tevatron Lifetime @ 80 $\mu b^{-1}$/sec 7.7 hours
- Init Tevatron Lifetime @ 160 $\mu b^{-1}$/sec 6.9 hours
- HEP store hours per week 98 hours
- Acc-Rec Transfer Efficiency @ 0x$10^{10}$ 86%
- Acc-Rec Transfer Efficiency @ 300x$10^{10}$ 86%
- Acc-Rec transfer time 0.5 hours
- Recycler lifetime 500 hours
- Recycler mining efficiency 97%
- Initial stack stack rate 17.5x$10^{10}$/hour
- Half rate stack size 150x$10^{10}$
- Maximum stack size 320x$10^{10}$
- Timeline Utilization Factor 75%
- Accumulator leftover factor 15%

With the above inputs we should have expected ~ 19 $pb^{-1}$/week in FY06 for a total of ~670 $pb^{-1}$

This is to be compared with 656* $pb^{-1}$ delivered in FY06

*After luminosity Correction

# Inputs Versus Time for Models

We implement the following default variations during the 12 trimesters in the period FY07-FY09 (Also assuming 22 hour long stores and 6 antiproton transfer shots as a default)

- Number of protons per bunch
- 260-270-270-270-270-270-270-270-270-270-270-270 x $10^9$
- HEP store hours per week
- 100-100-100-100-105-105-105-105-110-110-110-110 hours
- Acc-Rec Transfer Efficiency @ 0x$10^{10}$
- 87-87-88-89-90-90-90-91-91-91-91-91%
- Acc-Rec Transfer Efficiency @ 300x$10^{10}$
- 87-87-88-89-90-90-90-90-90-90-90-90%
- Acc-Rec transfer time
- 0.45-0.45-0.40-0.40-0.33-0.33-0.33-0.33-0.25-0.25-0.25-0.25 hours
- Initial stacking rate 18-42 x$10^{10}$/hour according to a pattern discussed below
- Timeline Utilization Factor 80-80-80-80-81-81-82-82-85-85-85-85%

Integrated luminosity in $pb^{-1}$ for 3 years

# Variations

Horizontally different stacking rate profiles.
Vertically other variations for mod2 profile.
Each variation independent.

| | mod2 | mod 3 | mod4 | mod5 | mod6 | mod7 | mod8 | mod9 | Mod 10 | Mod 11 | Mod 12 | Mod 13 Scen. II | Mod 14 | Mod 15 Scen. III | Mod 16 Scen. I | Mod 17 Scen. IV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| default | 5011 | 5030 | 5111 | 5154 | 5268 | 5362 | 5423 | 5501 | 5458 | 5573 | 5139 | 4463 | 5400 | 4723 | 4134 | 5239 |
| Protons a)fewer b)more | 4894, 5136 | | | | | | | | | | | | | | | |
| Timeline c) Less d) more | 4709, 5263 | | | | | | | | | | | | | | | |
| e) Tran eff. | 5058 | | | | | | | | | | | | | | | |
| f) Store length shorter | 4884 | | | | | | | | | | | | | | | |
| g) Trans time | 5093 | | | | | | | | | | | | | | | |
| h)Store length longer | 5064 | | | | | | | | | | | | | | | |
| Stack size i), j) | 5081, 4972 | | | | | | | | | | | | | | | |
| k) Store hours | 4731 | | | | | | | | | | | | | | | |
| Init life l) worse m) | 4979, 5050 | | | | | | | | | | | | | | | |

Integrated luminosity in $pb^{-1}$ for 3 years

# Variations

Horizontally different stacking rate profiles.
Vertically other variations for mod2 profile.
Each variation independent.

| | mod2 | mod 3 | mod4 | mod5 | mod6 | mod7 | mod8 | mod9 | Mod 10 | Mod 11 | Mod 12 | Mod 13 Scen. II | Mod 14 | Mod 15 Scen. III | Mod 16 Scen. I | Mod 17 Scen. IV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| default | 5011 | 5030 | 5111 | 5154 | 5268 | 5362 | 5423 | 5501 | 5458 | 5573 | 5139 | 4463 | 5400 | 4723 | 4134 | 5239 |
| n) RR life 300 h | 4958 | | | | | | | | | | | | | | | |
| o) Lum dens better | 5118 | | | | | | | | | | | | | | | |
| p) Acc left over 10% | 5062 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | |

# Scenario IV Inputs

Assuming 22 hour long stores and 6 antiproton transfer shots between stores

- Number of protons per bunch 260 x $10^9$
- (270 x $10^9$ in FY08 and FY09)
- Luminosity Density @ 100 x $10^{10}$ 81.71 $\mu b^{-1}$ /sec
- Luminosity Density @ 300 x $10^{10}$ 198.57 $\mu b^{-1}$/sec
- Init Tevatron Lifetime @ 80 $\mu b^{-1}$/sec 7.0 (7.7 in FY08 and FY09) hours
- Init Tevatron Lifetime @ 160 $\mu b^{-1}$/sec 6.5 (6.9 in FY08 and FY09) hours
- HEP store hours per week 100 (105 in FY08, FY09) hours
- Acc-Rec Transfer Eff. @ 0x$10^{10}$ 88,90,..90%
- Acc-Rec Transfer Eff. @ 300x$10^{10}$ 88,90,…,90%
- Acc-Rec transfer time 0.40, 0.25, 0.25, 0.25, 0.2, …,0.2 hours
- Recycler lifetime 500 hours
- Recycler mining efficiency 94%
- Initial stacking rate 18, 21, 25, 25, 35,…,35 x$10^{10}$/hour
- Half rate stack size 200x$10^{10}$
- Maximum stack size 400x$10^{10}$
- Timeline Utilization Factor 80%
- Accumulator leftover factor 15%

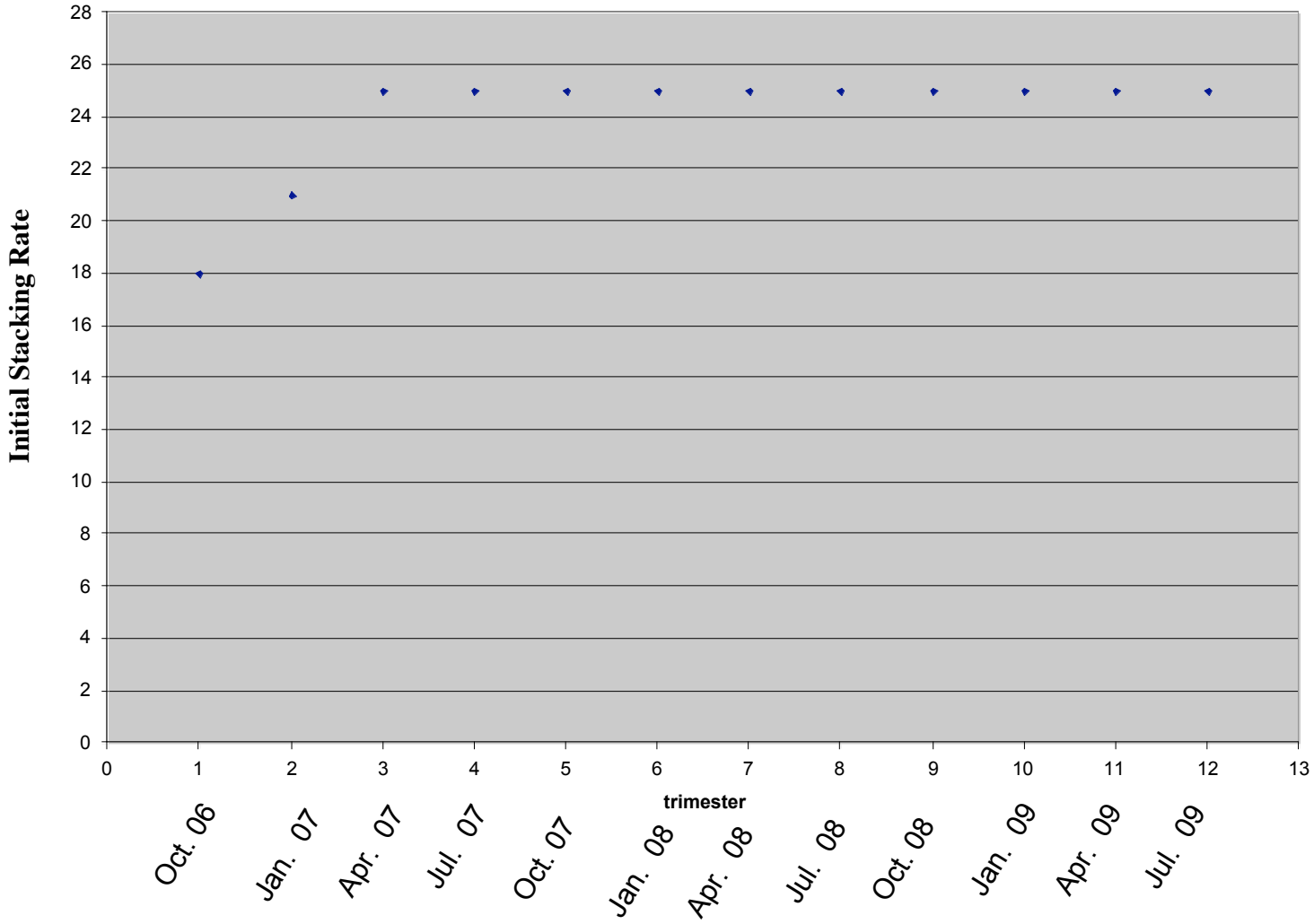
With above inputs we should expect ~ 5105 $pb^{-1}$ in 3 years

Equalizer I operational from April 2007 and no other improvement

# Initial Stacking Rate Profile

Scenario 2

4462.8 $pb^{-1}$ in 3 years

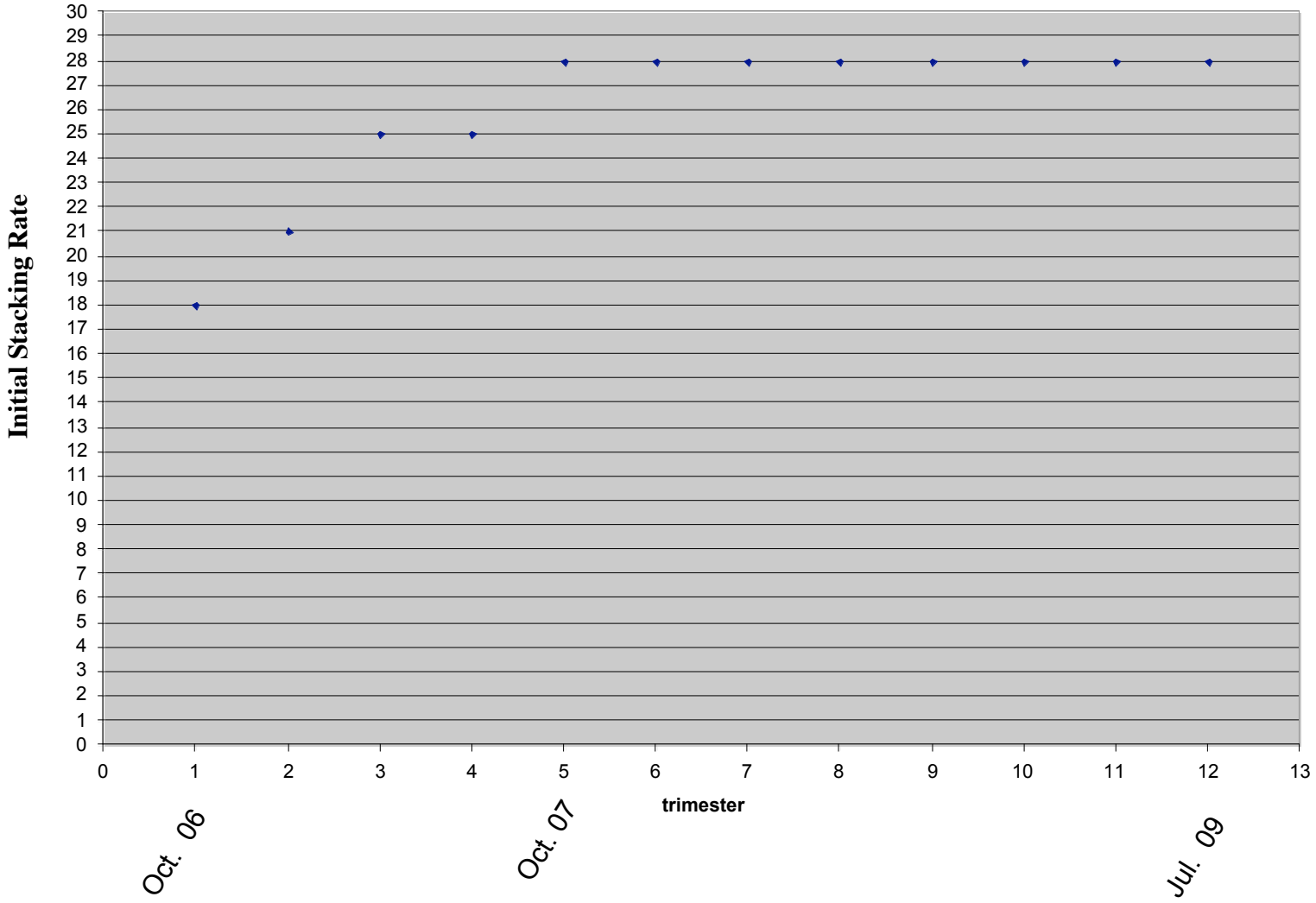


Equalizer I operational from April 2007 and 28mA/h from October 2007

# Initial Stacking Rate Profile

Scenario 3

4723 $pb^{-1}$ in 3 years

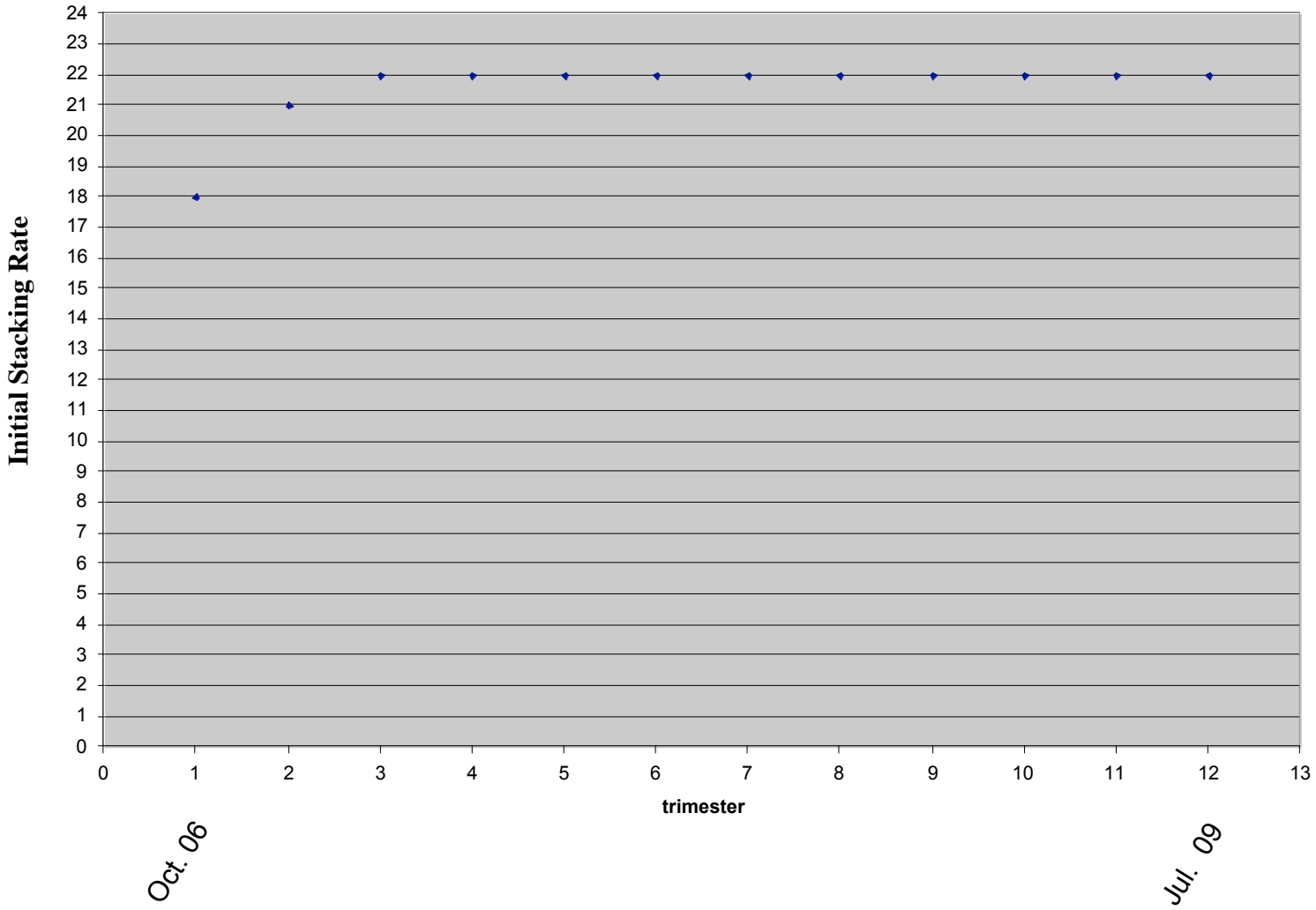


No other improvement since February 2007

# Initial Stacking Rate Profile

Scenario 1

4133.7 $pb^{-1}$ in 3 years

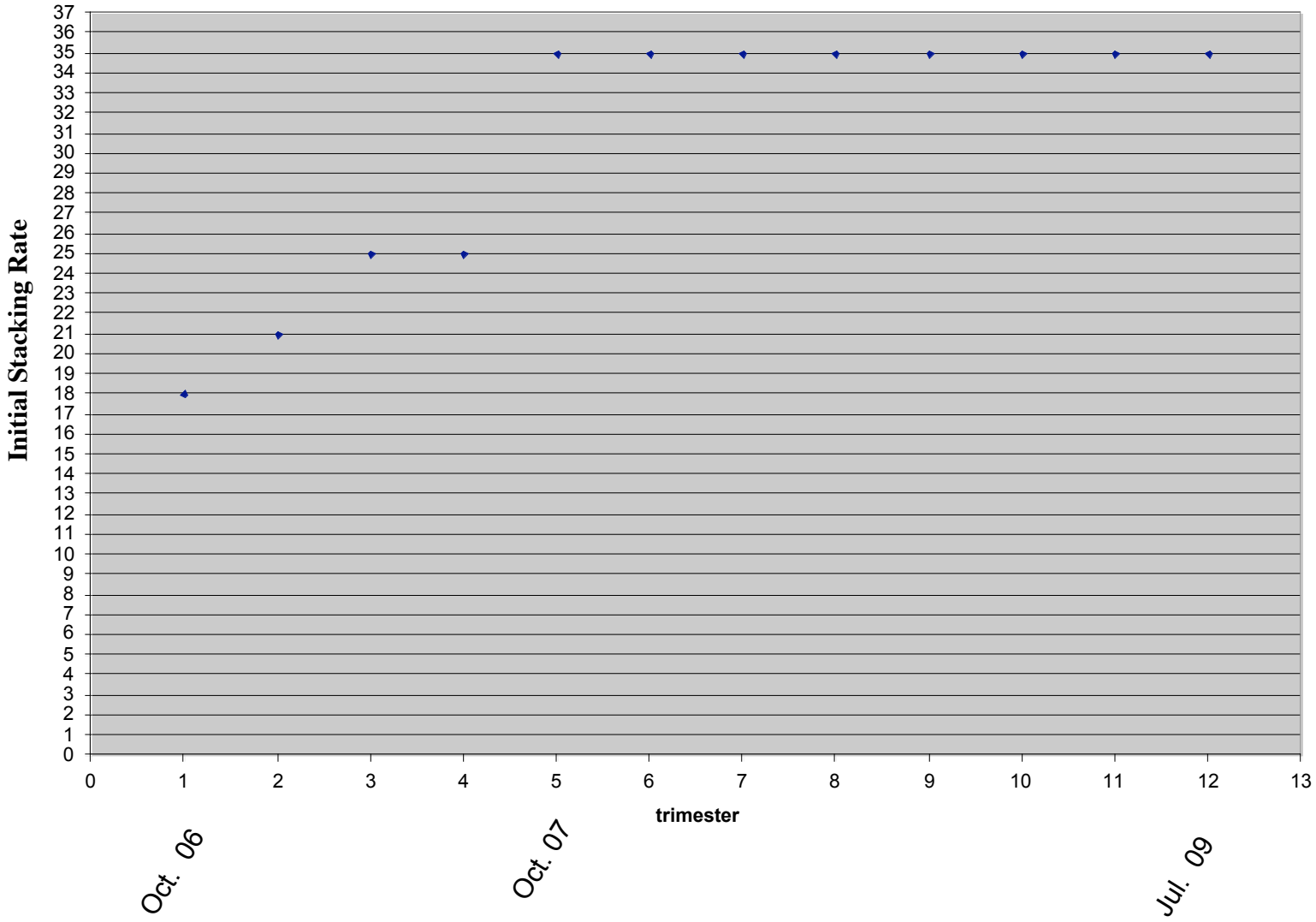


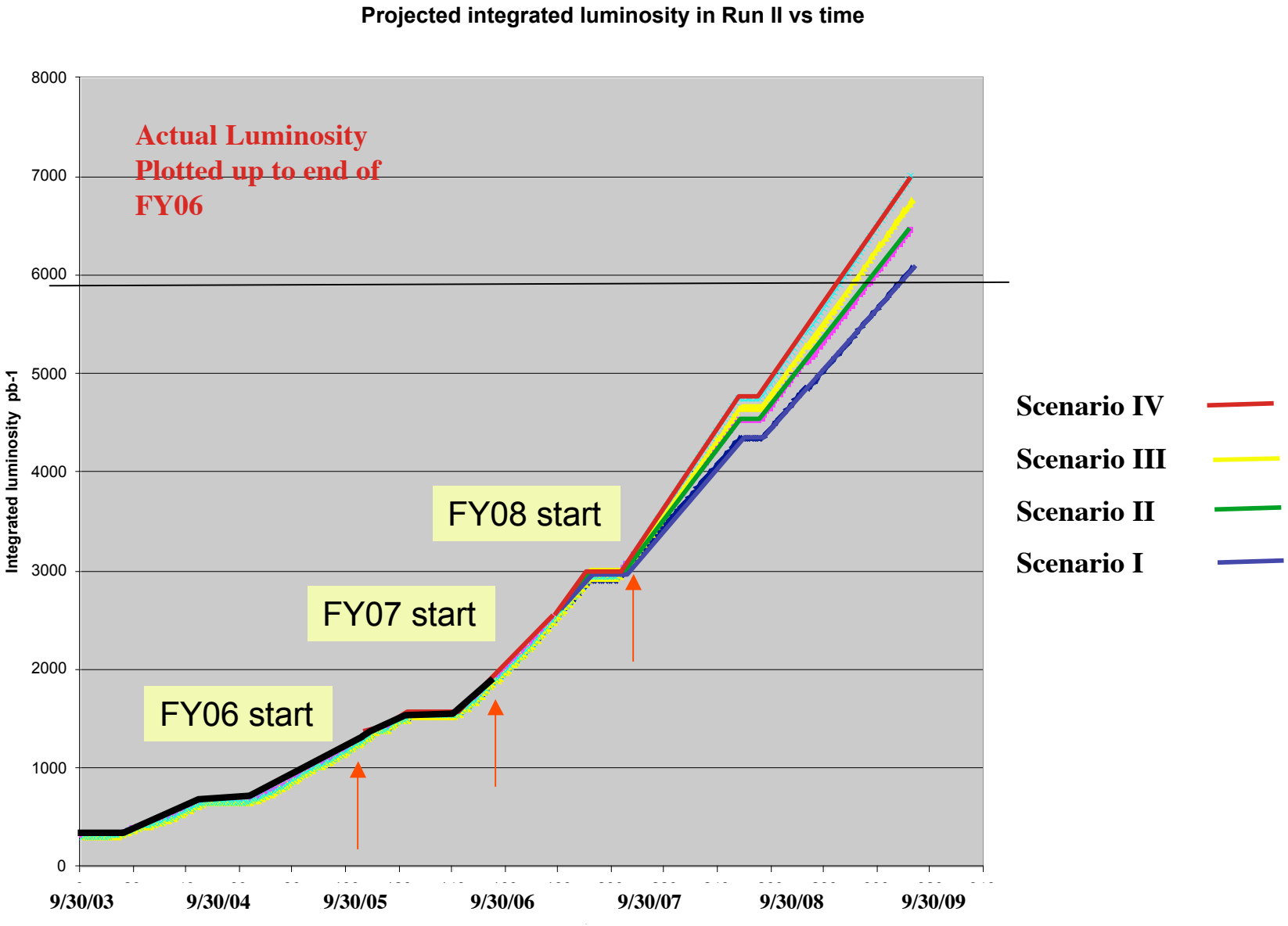
Equalizer I operational from April 2007 and Equalizer II operational from October 2007

# Initial Stacking Rate Profile

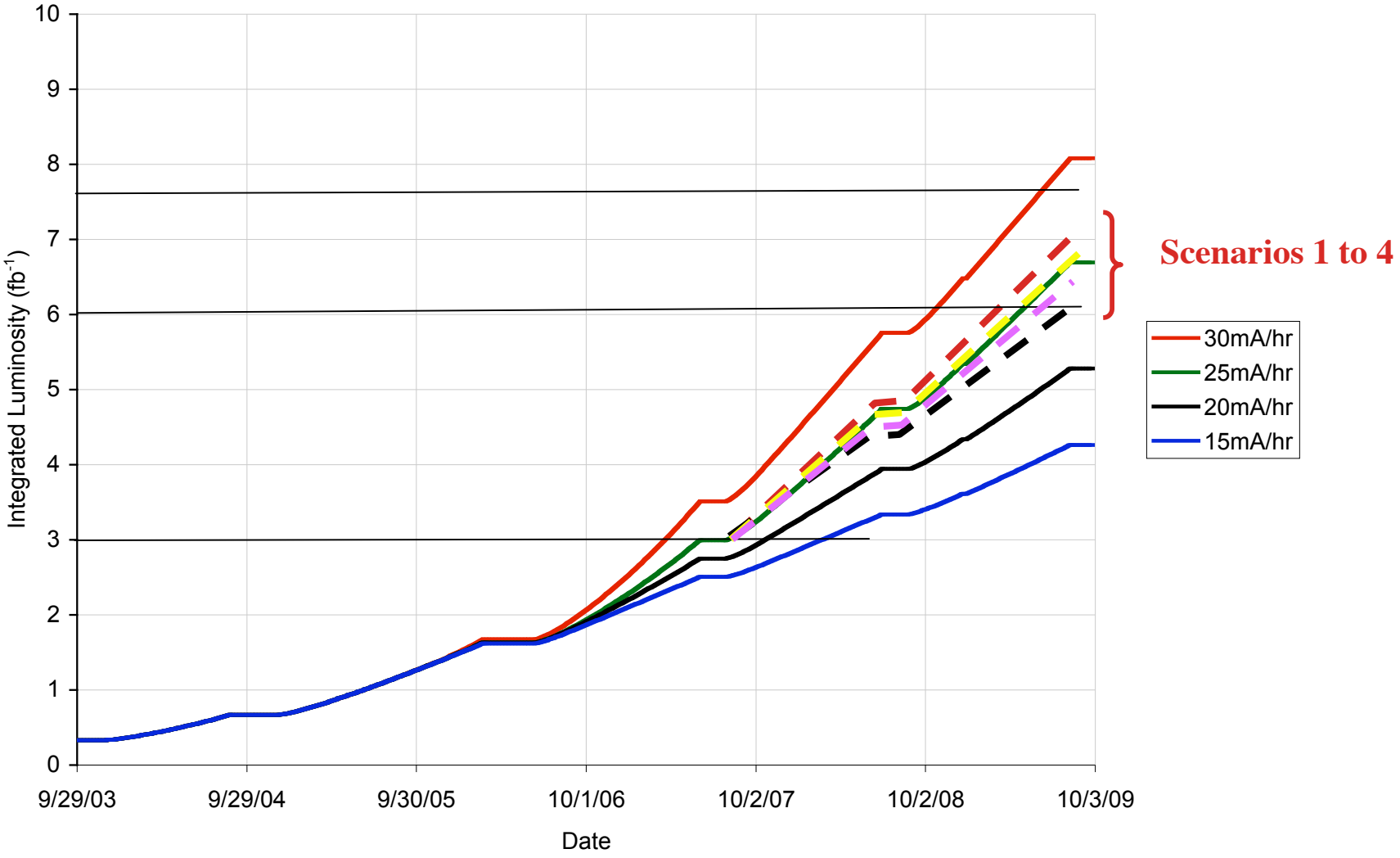
Scenario 4

5238.7 $pb^{-1}$ in 3 years




Projected integrated luminosity in Run II vs time
Actual Luminosity
Plotted up to end of
FY06
FY06 start
FY07 start
FY08 start
Integrated luminosity pb-1
8000
7000
6000
5000
4000
3000
2000
1000
0
9/30/03
9/30/04
9/30/05
9/30/06
9/30/07
9/30/08
9/30/09
Scenario IV
Scenario III
Scenario II
Scenario I

# All Projection Curves



# Maintenance and Reliability

- Trends in system failures and major vulnerabilities are tracked and mitigated as soon as possible. Examples of past problems:
  - Abort kicker prefires.
    - After extensive work, no prefires in over two years.
  - Quench Protection Monitor failures causing aborts.
    - Major overhaul of the system has resulted in 0 false aborts this past year due to the QPM system
  - Quench Protection Monitor Heart beat sped up to prevent damage during quenches
  - Linac 7835 Power Amplifier tubes.
    - Working group formed that worked with the vendor and ultimately placed a "reserve stock" order for 12 tubes.
    - 12 tubes are in reserve and new tubes are cycled through the reserve to keep the tubes fresh i.e. a new tube goes into reserve and a reserve tube is withdrawn.
    - Vendor has made a major upgrade to their facility and to their process control.

# Vulnerabilities

- Booster Transformers and Switch Gear.
  - Routine maintenance showed pending problems with 30+ year old booster transformers and switch gear.
  - Switch gear was no longer manufactured and parts were unavailable and would have to be locally fabricated.
    - New transformers and switch gear were procured and installed during the past long shutdown.
    - New transformers were configured so the old transformers could be used as spares in case of emergency and would minimize any subsequent downtime.
- Master Substation transformer
  - Originally a $1.2M replacement cost for transformer only.
    - Developed a plan with FESS that would allow the transfer of power to a different transformer with new switchgear.
  - TEC is now $567k

# Tools to Track Problems

- The Primary tool available to all support departments is the Downtime log and the Downtime Summary.
- This is an electronic database in which any downtime is entered by the Operations Crew.
- The downtime is captured by machine and system.
- Available on the Accelerator Division Web Page for internal viewing.
- The system allows the compilation of downtimes to indicate developing fault trends.
- System failures are also discussed at daily 9:00 AM meeting to develop possible mitigation strategies.

# Shutdown Injury Statistics

- Shutdown 2003
  - 10 week shutdown
  - 273 Technicians, 87 were on loan from other divisions
  - 18 injuries – 13 shutdown related
  - 7 first aid
  - 6 recordable
  - 0 dart

# Shutdown Injury Statistics

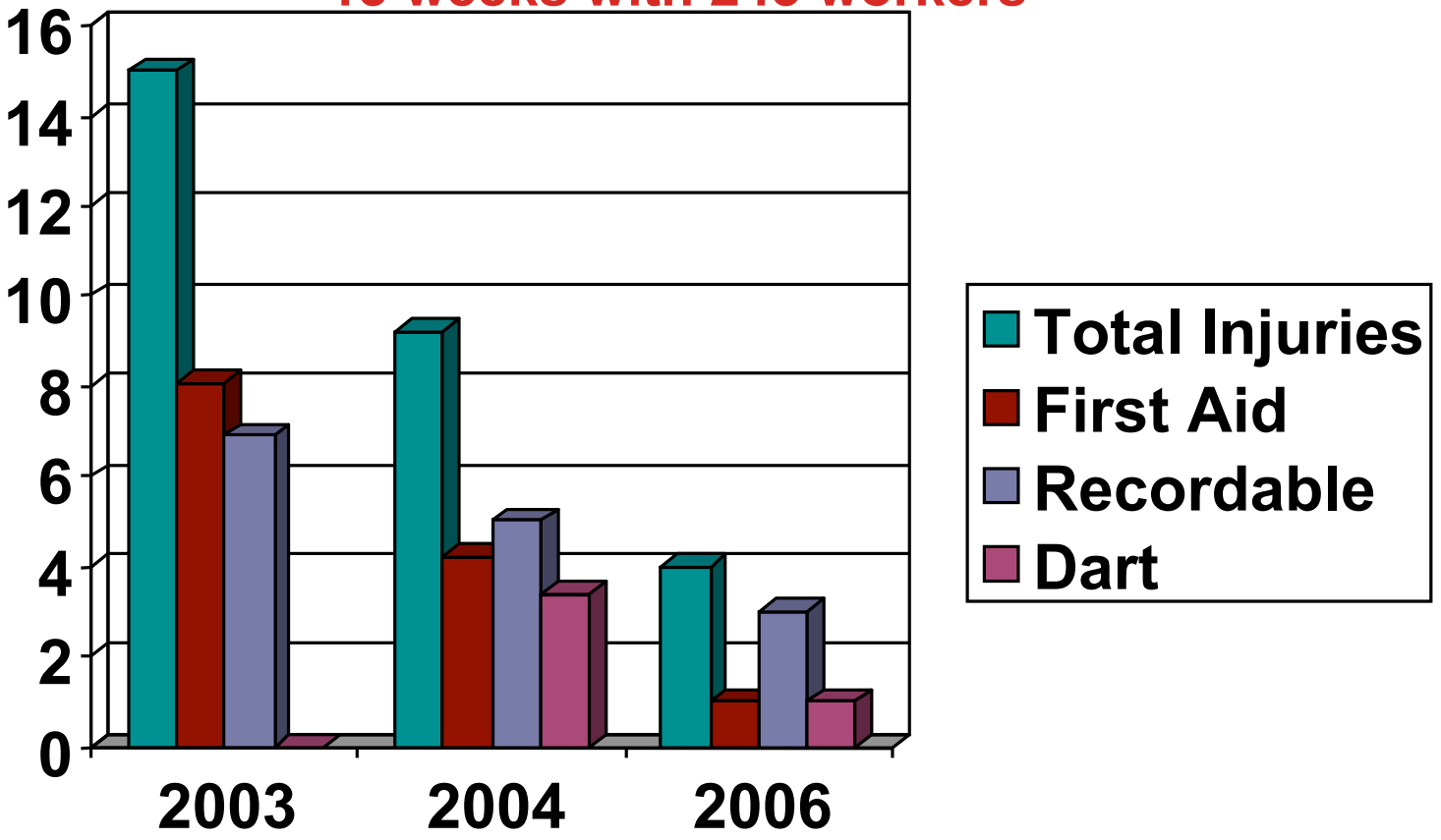
- Shutdown 2004
  - 13 week shutdown became 14 weeks
  - 269 Technicians, 79 were on loan from other divisions
  - 11 injuries – 11 shutdown related
  - 5 first aid
  - 6 recordable
  - 4 dart

# Shutdown Injury Statistics

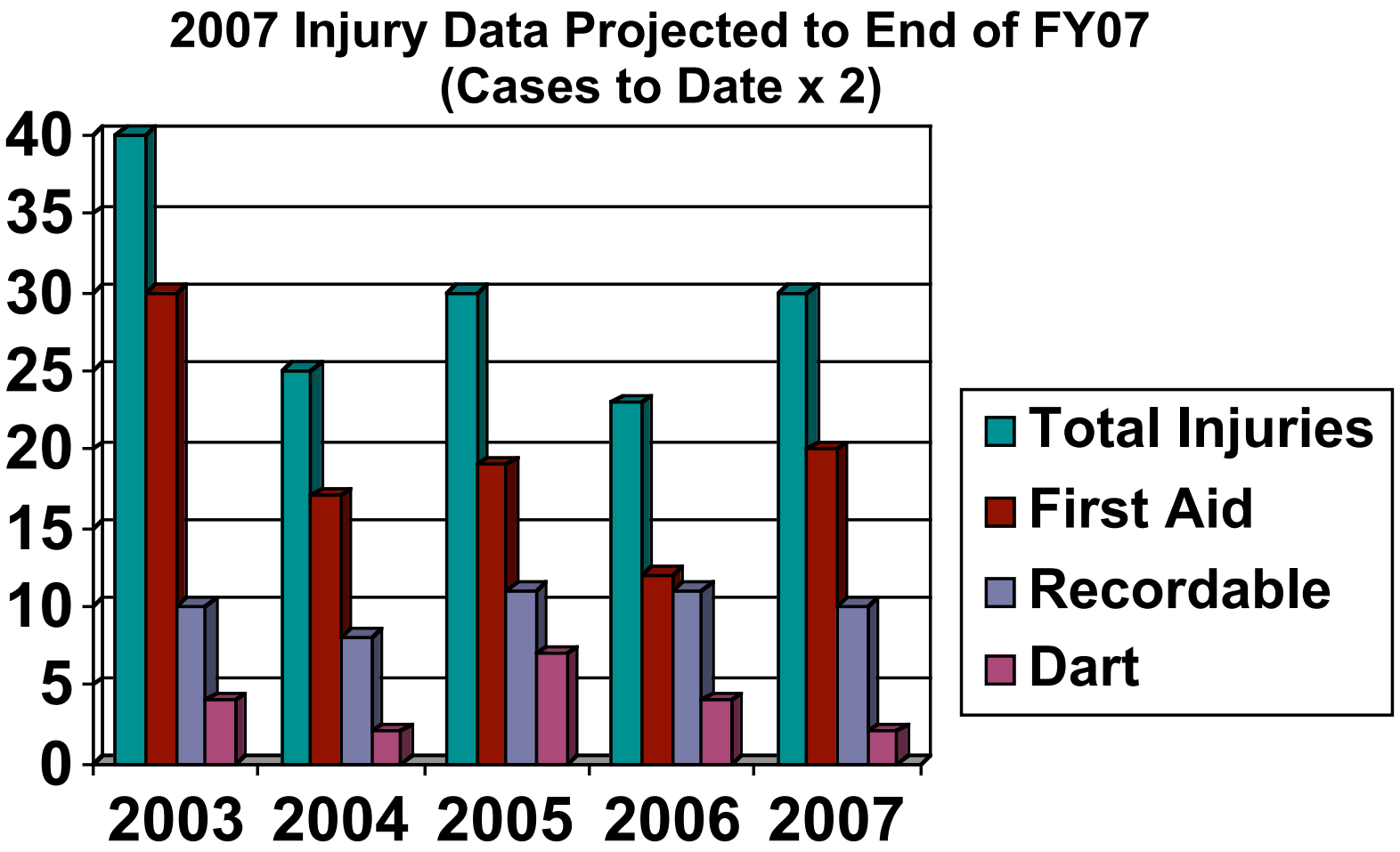
- Shutdown 2006
  - 13 week shutdown
  - 243 Technicians, 48 were on loan from other divisions
  - 5 injuries – 4 shutdown related
  - 1 first aid
  - 3 recordable
  - 1 dart

# Shutdown Injury Statistics

**Data normalized to 2006 shutdown**
**13 weeks with 243 workers**

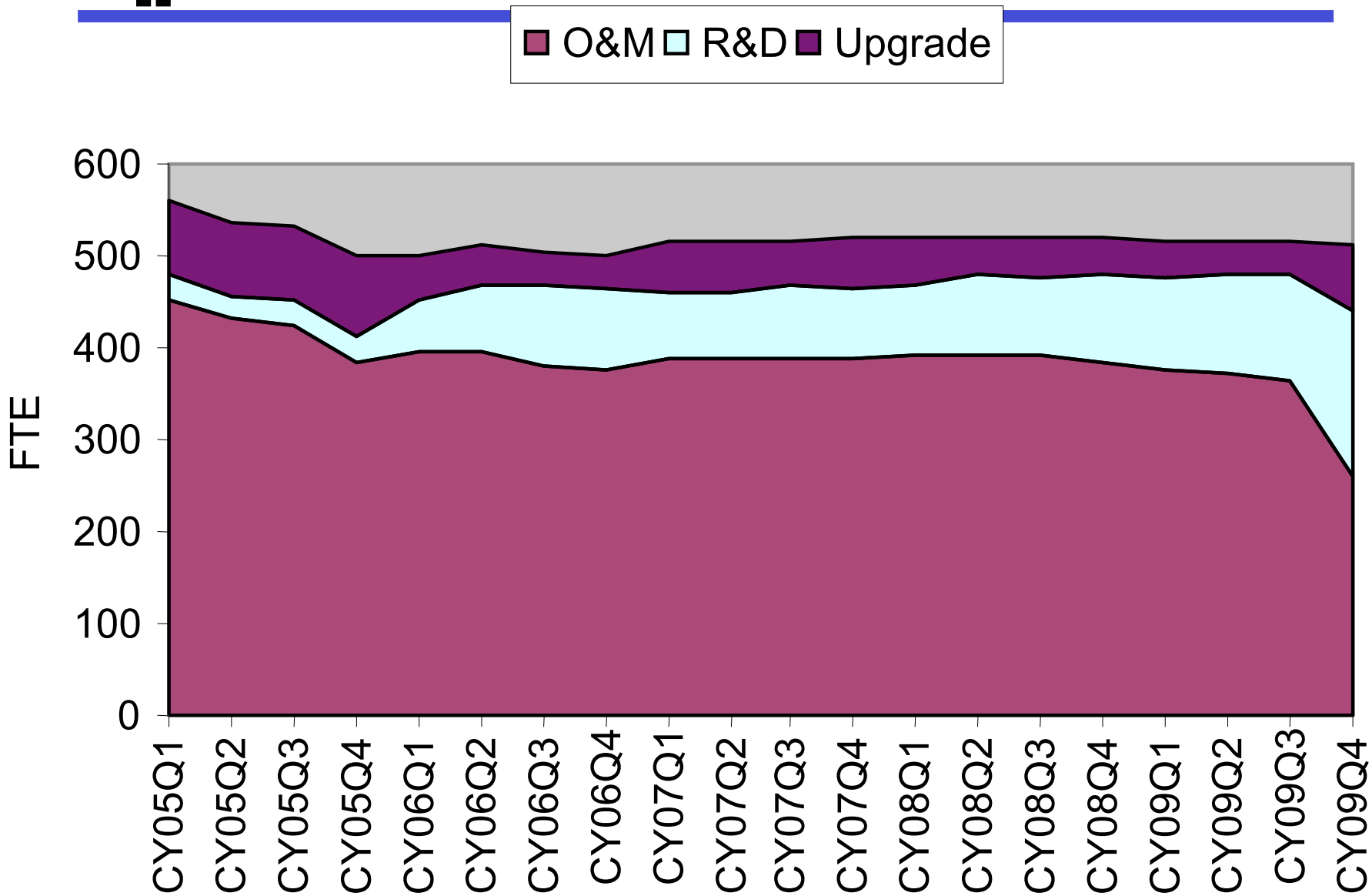


# Injuries by Fiscal Year

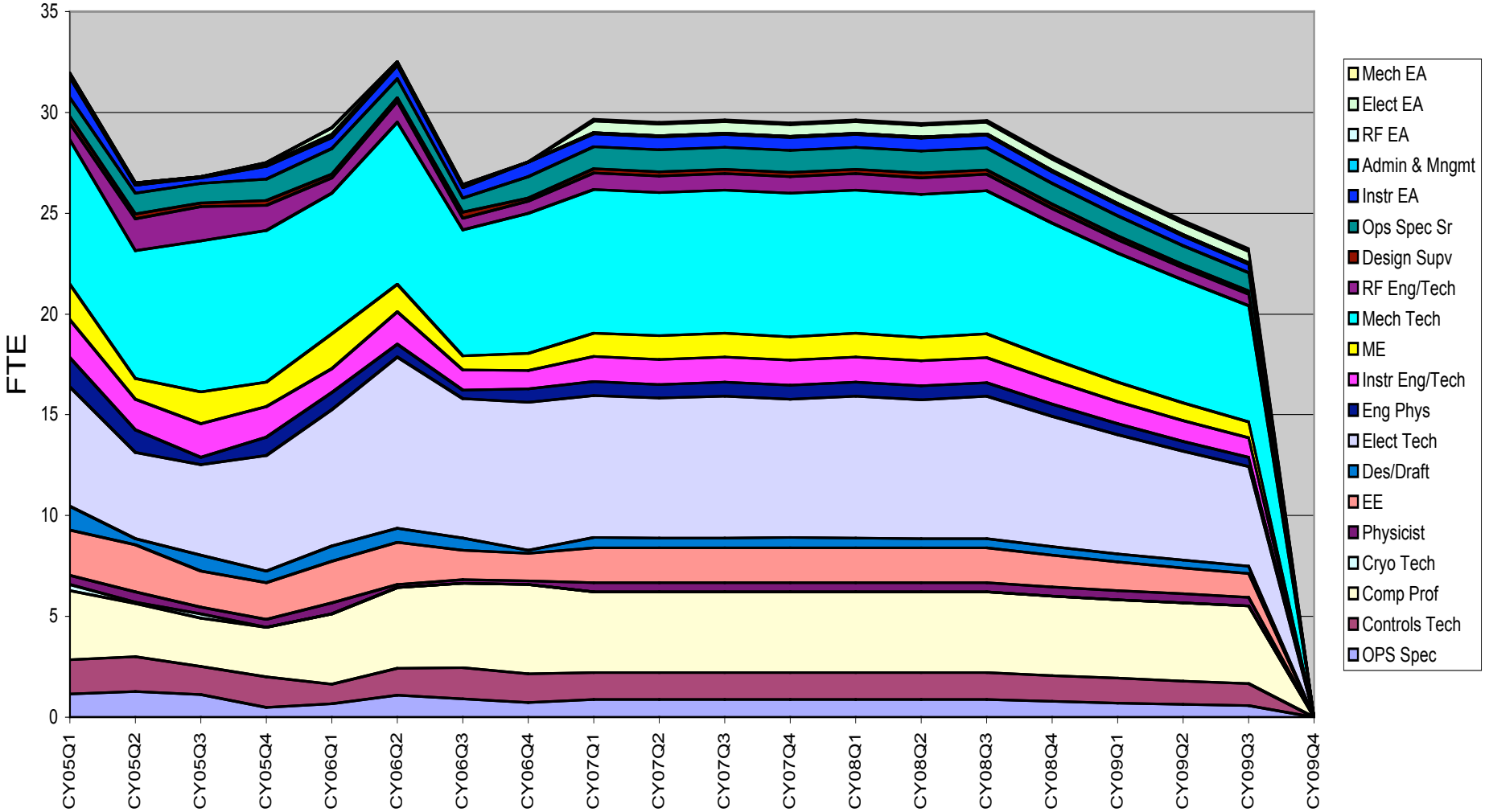


# Highlights of Safety Plan

- Grass Roots Safety Committee
- Improved feedback mechanism for employees
- Quarterly ES&H Newsletter
- Focus on maintaining areas


O&M
R&D
Upgrade
FTE
600
500
400
300
200
100
0
CY05Q1
CY05Q2
CY05Q3
CY05Q4
CY06Q1
CY06Q2
CY06Q3
CY06Q4
CY07Q1
CY07Q2
CY07Q3
CY07Q4
CY08Q1
CY08Q2
CY08Q3
CY08Q4
CY09Q1
CY09Q2
CY09Q3
CY09Q4

# Tevatron Maint



# AD Budget

| | | | 'FY07 LOADED | FY08 PBR LOADED | FY09 REQUEST LOADED |
|---|---|---|---|---|---|
| 1.1 Accelerators | 1.1.1 Accelerator Maintenance and Operations | 1.1.1.1 Proton Source | 10,466.8 | 10,466.1 | 10,436.6 |
| | | 1.1.1.2 Main Injector | 8,277.2 | 9,019.8 | 9,964.1 |
| | | 1.1.1.3 Antiproton Source | 6,876.6 | 6,904.6 | 6,205.5 |
| | | 1.1.1.4 Recycler including Electron Cooling | 4,957.5 | 5,208.3 | 5,203.2 |
| | | 1.1.1.5 Tevatron | 10,725.6 | 9,283.4 | 9,325.9 |
| | | 1.1.1.6 Cryogenics | 12,310.7 | 11,518.1 | 11,589.9 |
| | | 1.1.1.7 Accelerator Operations Department | 6,582.7 | 6,565.2 | 6,563.9 |
| | | 1.1.1.8 Accelerator Integration Department | 3,326.9 | 3,590.4 | 3,587.7 |
| | | 1.1.1.9 Magnet Repair | 2,300.5 | 2,003.0 | 1,960.2 |
| | | 1.1.1.10 Tevatron Magnet Measurement Improvements | 0.0 | 0.0 | 0.0 |
| | | 1.1.1.11 Programmatic Electrical Energy | 20,875.0 | 25,880.0 | 29,444.0 |
| | | 1.1.1.12 Tevatron Cold Testing | 0.0 | 0.0 | 0.0 |
| | | 1.1.1.13 Conventional Magnet Testing | 405.7 | 0.0 | 0.0 |
| | | 1.1.1.15 Common Accelerator Controls | 3,202.6 | 3,377.3 | 3,463.8 |
| | 1.1.1 Accelerator Maintenance and Operations Total | | 90,307.8 | 93,816.3 | 97,744.8 |
| | 1.1.2 Accelerator Upgrades | 1.1.2.1 Proton Plan/Phase I | 10,855.6 | 3,941.9 | 324.4 |
| | | 1.1.2.2 Accelerator Upgrades - Other | 3,668.8 | 0.0 | 1,931.7 |
| | | 1.1.2.3 Run II Luminosity Upgrades | 578.6 | 0.0 | 0.0 |
| | | 1.1.2.4 Run II Plan Reliability Upgrades | 0.0 | 0.0 | 0.0 |
| | | 1.1.2.6 Super NuMI | 160.5 | 0.0 | 0.0 |
| | 1.1.2 Accelerator Upgrades Total | | 15,263.4 | 3,941.9 | 2,256.1 |
| 1.1 Accelerators Total | | | 105,571.2 | 97,758.2 | 100,000.9 |
| 1.5 Experimental Initiatives | 1.5.2 External Beamlines & Fixed Target Exps | 1.5.2.7 External Beamlines | 4,026.6 | 3,972.1 | 3,993.6 |
| | | | | | |
| | 1.5.2 External Beamlines & Fixed Target Exps Total | | 5,216.8 | 5,567.0 | 5,467.5 |
| 1.5 Experimental Initiatives Total | | | 5,216.8 | 5,567.0 | 5,467.5 |
| 1.6 Neutrino Experiments | 1.6.1 NuMI / MINOS | 1.6.1.1 Beamline | 1,992.3 | 2,645.0 | 2,624.5 |
| | | | | | |
| | | 1.6.1.7 Numi Beam Line Spares | 2,541.7 | 2,387.3 | 2,246.9 |
| | | | | | |

# Summary and Conclusions

- Run II has made dramatic progress in the past year in terms of delivered luminosity
  - Tevatron performance is still improving
  - Stacking rate continues to improve
  - Projections indicate that we have a good chance to meet the luminosity goals
- Detailed Manpower projections have been made to the end of FY2009
- Safety is improving and is still an area of focus